$NiSe_2$ Modified Carbon Fibre Cloth as the High-Performance Electrode for Thermally Chargeable Supercapacitors

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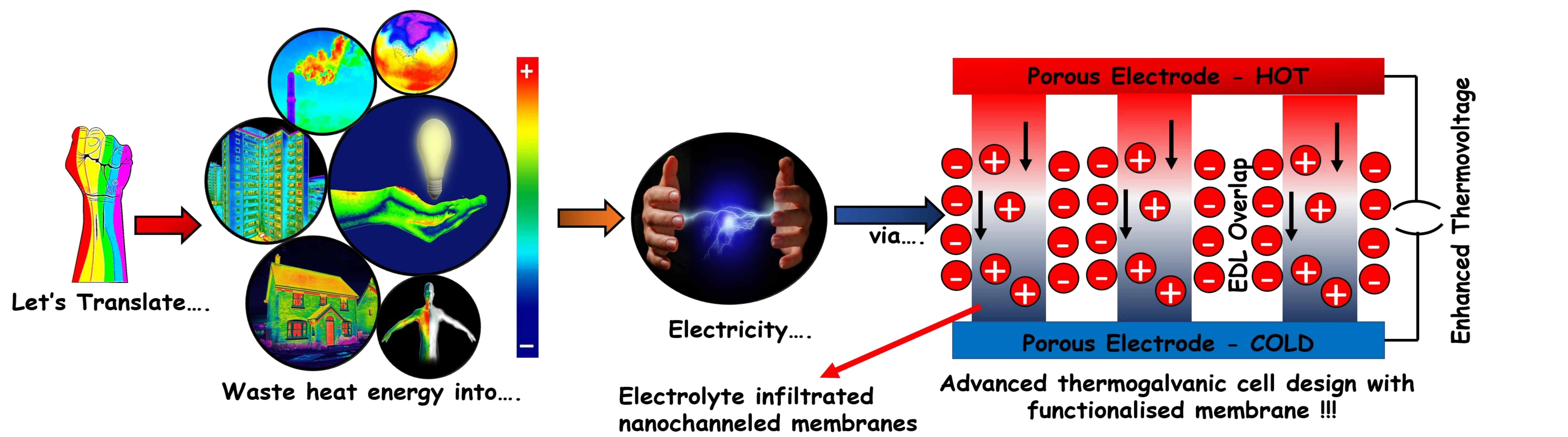
Introduction to "TRANSLATE"



Schematic representation of sustainable energy conversion from low grade waste heat through nanofluidic channels.

- TRANSLATE – Conversion of waste heat into electricity
- Developing novel porous electrodes and functionalised membranes for advanced thermogalvanic cell and thermophoretic design.
- Enhancing the Soret effect to obtain a high thermo-voltage for energy storage applications.

Research Objective

- Development and optimization of novel electrode material with excellent electrochemical activity for Thermally Chargeable Supercapacitors (TCSs).
- Understanding of thermo-ionic diffusion via nanochannels.
- To enhance the energy storage capacity of TCSs through the synergistic effect of ionic diffusion and Soret effect.

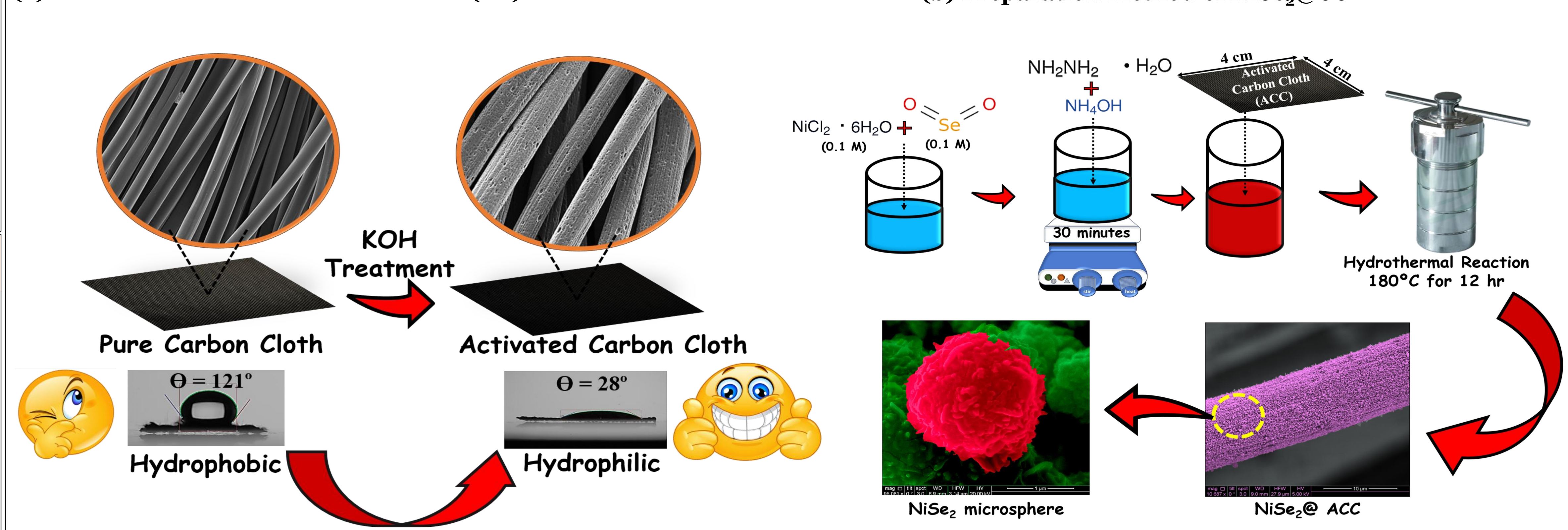
Motivation

- Nickel Selenide is known for its excellent conductivity and enhanced electrochemical activity.
- Flexible carbon cloth (CC) can provide high mechanical integrity and large surface area.
- Direct integration of metal selenide on conducting substrates increase the stability and specific capacity

Electrode Preparation and Cell Fabrication

(a) Chemical Activation of carbon cloth (CC)

(b) Preparation method of $NiSe_2$@CC



Schematic representation of $NiSe_2$ microsphere@ACC preparation

Results and discussion

Structural characterization and surface area analysis of $NiSe_2$ microspheres

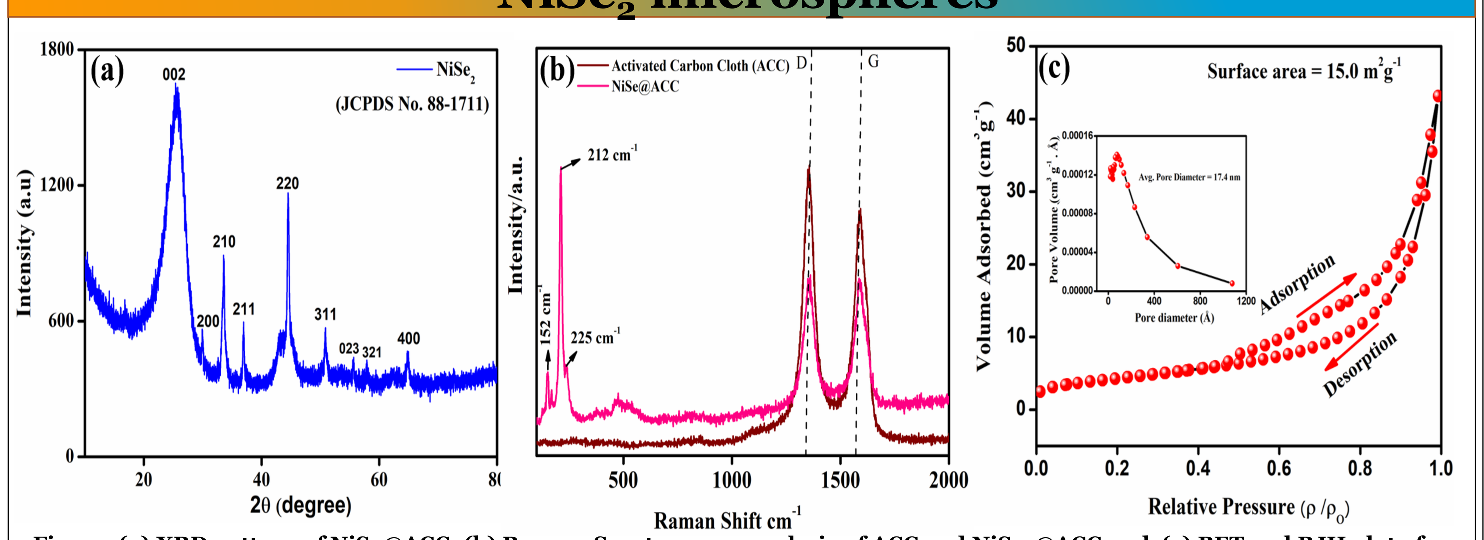
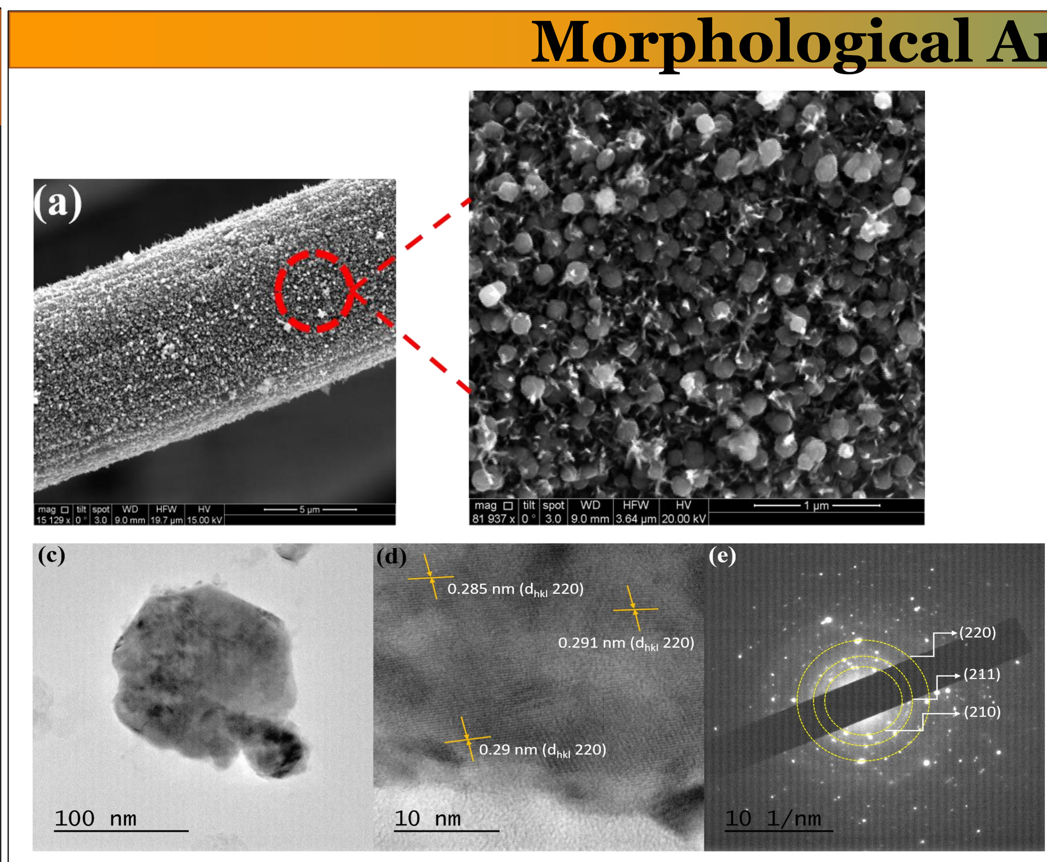
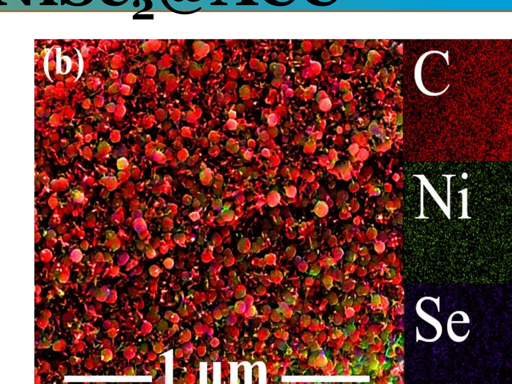


Figure. (a) XRD pattern of NiSe@ACC, (b) Raman Spectroscopy analysis of ACC and $NiSe_2$@ACC and (c) BET and BJH plot of NiSe@ACC

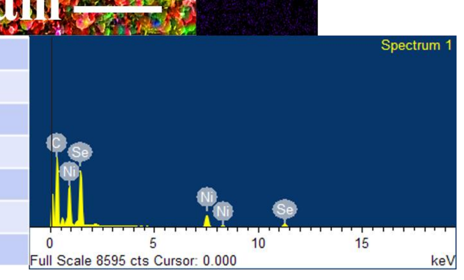
- The XRD pattern confirms the NiSe2cubic crustal structure.
- The Raman spectra further supports the growth of $NiSe_2$ on ACC and shows sharp peak at 212 cm^{-1} and an other peak at 225 cm^{-1} which are attributed to Ni-Se vibrations.
- The BET and BJH plot reveals the surface area and average pore diameter of $NiSe_2$ microsphere to be 15.0 m2 g-1 and 17 nm, respectively.

Morphological Analysis of $NiSe_2$@ACC





Element	Weight%	Atomic%
C K	72.81	93.87
Ni K	11.78	3.11
Se L	15.42	3.02
Totals	100.00	



- The SEM images confirms the integration and growth of $NiSe_2$ microspheres on carbon cloth.
- The Elemental mapping and EDX spectra confirms the chemical composition of $NiSe_2$ on carbon cloth with appropriate atomic weight distribution.
- The TEM image further confirms the formation of $NiSe_2$ microsphere.
- The d spacing obtained from HR-TEM corresponds to 220 plane, which matches well with the XRD pattern and confirms the formation $NiSe_2$ cubic crystal structure.

Figure . (a) SEM image of NiSe microsphere prepared through hydrothermal process at 180 °C for 12, (b) Elemental mapping and EDAX Spectra NiSe microsphere and (c-e) TEM images of $NiSe_2$ microsphere

Electrochemical performance of $NiSe_2$@ACC

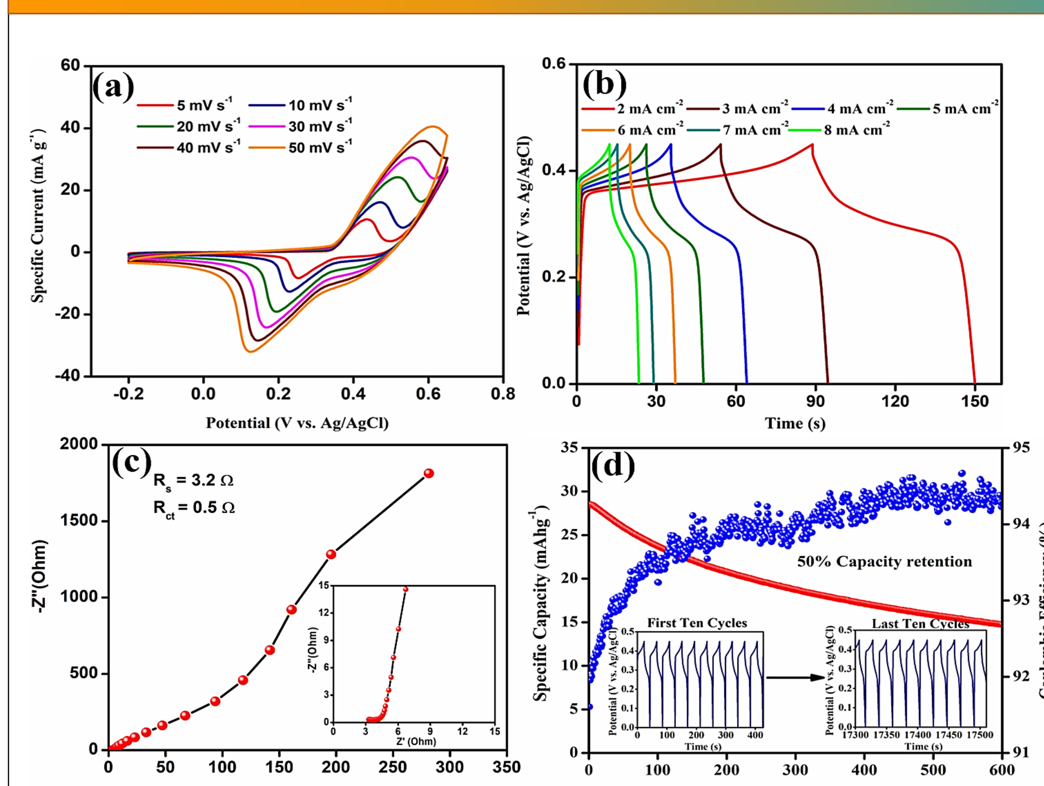


Figure. (a) CV profile at different scan rates (5 to 50 mV s^{-1}), (b) (a) GCD profile of a at different current densities (2 mA g^{-1} to 10 mA g^{-1}) (c) Nyquist plot and (d) Stability and Coulombic Efficiency of $NiSe_2$@CC electrode

- The electrochemical performance of $NiSe_2$@ACC electrode was evaluated in three-electrode configuration using 1 M NaOH electrolyte
- CV profile shows the explicit oxidation and reduction peaks due to the $Ni^{2+/3+}$ redox couples.
- GCD graph at various specific current denotes the battery-type charge storage process at the electrodes.
- At 1 mA cm^{-2} the electrode shows a high specific capacity of 36 $mAhg^{-1}$ and decreases to 26 $mAhg^{-1}$ at 8 mA g^{-1}.
- $NiSe_2$@ACC electrode exhibits a good capacitive retention and coulombic efficiency of 50% and 94.5% over 600 charge-discharge cycles, respectively.

$NiSe_2$// $NiSe_2$ electrodes based thermo-cell

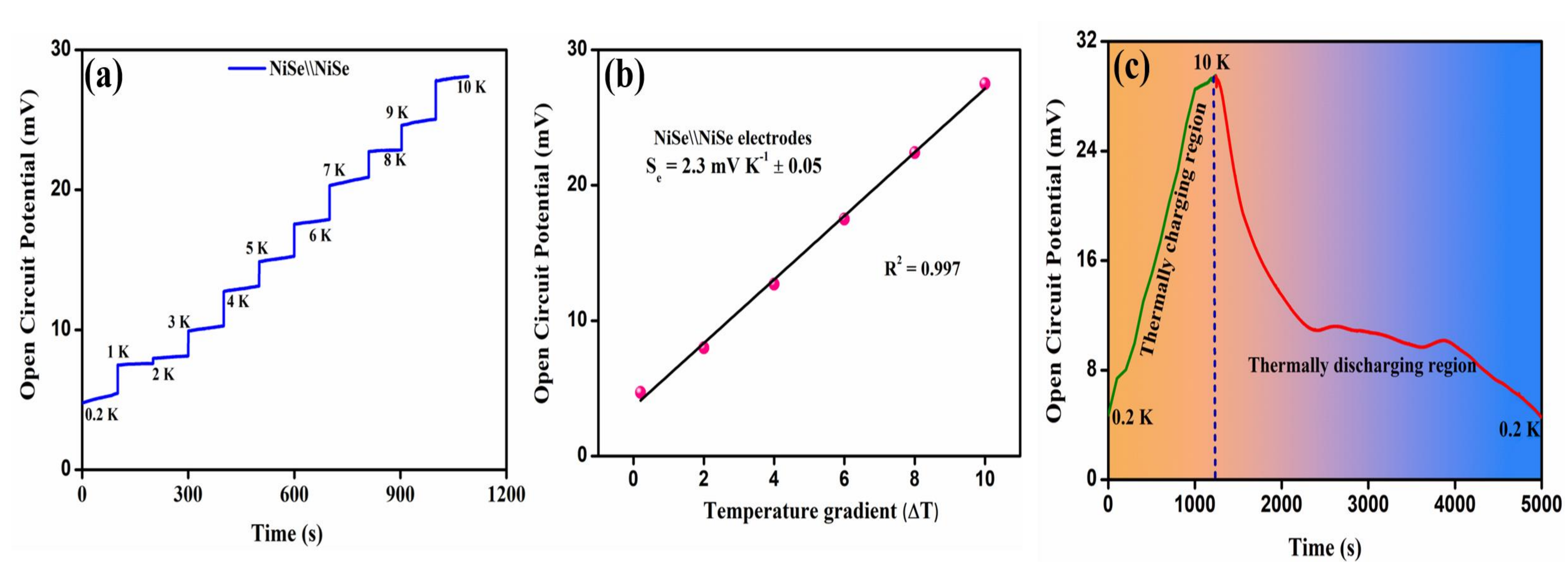


Figure. (a) Open circuit voltage obtained at different temperature gradient (0.2 K to 10 K), (b) Linear fitting of open circuit voltage Vs. temperature gradient (d) Thermally charging and discharging cycle of $NiSe^2$//$NiSe_2$ symmetric thermo-electrochemical cell.

- The thermo- cell is assembled by sandwiching the 1 M NaOH infiltrated celgard separator between two symmetric porous $NiSe_2$ electrodes
- The thermo-voltage obtained from $NiSe_2$//$NiSe_2$ based thermo-cell is 2.3 mV K^{-1} ± 0.05.
- This results can be further improved by increasing specific surface area and can extended to thermally chargeable supercapacitor application.

Conclusion and Future Study

- **$NiSe_2$//$NiSe_2$ symmetric thermo-cell has been successfully fabricated and a thermo-voltage of 2.3 mV K^{-1} ± 0.05 is obtained.**
- **From this study, it can be concluded that $NiSe_2$@ACC can be a better choice of porous electrode when compared to metal electrodes for conventional supercapacitor or thermo-cell application.**
- **This work can be extended to fabricate sustainable ternary metal selenides or sulphides (CuFeSe, etc.,)based chalcogenides for high performance thermo-energy application.**
- **Further, research on improving thermo-voltage is in progress.**

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References

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